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Bacterial control with UV lights in the food industry in Nicaragua

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ABSTRACT

This article documents the application of the methodology of a descriptive industrial engineering project for the food industry, being one of the most important in our country, but also one of the most susceptible to bacterial contamination problems. Food-borne illness is a serious problem that affects millions of people every year. What can we do about it? The solution lies in UV lights.

UV lights are an effective and safe way to control the proliferation of bacteria in the food industry. By exposing food and surfaces to these lights, up to 99.9% of the bacteria present are eliminated, without the need for chemicals or complicated processes. In addition, UV lights are environmentally friendly and do not generate toxic waste.

INTRODUCTION

Bacterial control is a topic present in various fields, such as medicine and the food industry. Bacteria can cause illness and contaminate products, which can have serious consequences for human health and the environment.

In the food industry, bacteria can cause consumer infection and poisoning. Infection is caused by ingesting food contaminated with live bacteria that enter the host and cause illness.

Poisoning, on the other hand, occurs when food is ingested that has previously been contaminated with bacteria that produce toxins, and the latter are the ones that cause the disease.

Ultraviolet (UV) light, particularly in the 254 nm wavelength band, has germicidal properties that affect the DNA and RNA of bacteria, preventing their replication and survival. This work consists of developing a project that addresses the technical and safety challenges related to bacterial control using UV light in industrial environments.

Consequently, the UV light bacterial control project aims to develop an effective and cost-effective prototype, using UV-C light as a bacterial control method, using UV-C light. To do this, a device that emits UV-C radiation in a controlled way will be implemented, applying this to cultures of bacteria, present in an agar culture medium, it is intended to see the growth of bacteria on certain surfaces, where a distinction will be made between cultures that were exposed to UV-C light and those that were not, this will be evaluated in laboratory tests.

METHOD

The methodological design of the project is descriptive and experimental cross-sectional that includes a series of carefully planned steps to ensure the effectiveness of bacterial control with UV lights in the food industry.

The methodology used in this research was divided into three main phases: the first phase consisted of the bibliographic review of previous studies related to bacterial control in the food industry, the second phase included the selection of samples and the performance of experiments, and the third phase consisted of the analysis of the results obtained.

In the first phase of the research, a comprehensive search of the available scientific literature on bacterial control in the food industry was carried out. Articles, reports, and publications relevant to the topic of study were analyzed. In the second phase, different residue samples were selected in specific facilities to be implanted in a soybean agar culture to enhance the growth of bacteria and exposed to UV light for different periods. Finally, the results obtained were analyzed and compared with the data obtained in previous studies. Taking as research questions:

What is the importance of using UV light for bacterial control in the food industry?

What are the quality conditions of the installations in general in the industry?

What are the aspects that can influence bacterial growth within these facilities in the industry?

The food industry is a direct beneficiary, since in general terms it has a higher degree of cross-contamination, on the other hand, as an indirect beneficiary come the other industries that also follow in the footsteps of the food industry using UV light, it is possible to achieve a disinfection of 99.9%.

RESULTS.

The results obtained in the research show that the use of UV lights is highly effective for bacterial control in the food industry. Compared to other methods, UV lights achieved a significant reduction in the amount of bacteria present in industry facilities. In addition, it was found that this method does not adversely affect the organoleptic properties of the food and/or the interaction of the engineering work, meaning that the products treated with UV lights maintain their original taste, texture, and aroma.

The implementation of bacterial control with UV lights in the food industry is expected to have a significant impact on food safety. The number of cases of food-borne illness is expected to decrease drastically, resulting in increased consumer confidence in food products.

In addition, the implementation of this bacterial control method is expected to be cost-effective for companies in the food industry in the long run. Although there may be upfront costs associated with the purchase and installation of UV light equipment, these costs are expected to be offset over time due to a decrease in cleaning and disinfecting costs, as well as a decrease in the number of contaminated products that need to be recalled.

These results are very important for the food industry because they allow us to improve the safety and quality of food without compromising its appearance or taste. In addition, the use of UV lights as a method of bacterial control is more sustainable and economical than other methods that require the use of chemicals or high temperatures. In summary, this research demonstrates that the use of UV lights is a viable and effective alternative for bacterial control in the food industry.

Once the effectiveness of UV lights has been presented, it can be recommended to install UV lights at the critical points identified during the investigation. Thorough training will be conducted to ensure that all personnel involved in the process understand the importance of bacterial control and how the UV light system works.

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DISCUSSION.

1. UV

Ultraviolet (UV) radiation is a form of non-ionizing radiation that is emitted by the sun and artificial sources, such as tanning beds. Although it offers some benefits to people, such as the production of vitamin D, it can also cause health risks. Our natural source of UV radiation is the sun. (Spanish CDC, 2021).

1.1. Types of radiation (UV)

(UVA): UVA rays are the ultraviolet rays that have the least energy. They penetrate the dermis (a deeper layer of the skin). Although at first glance they are harmless because they do not cause pain or burns, these rays are responsible for skin photoaging and can cause the appearance of spots on the skin. (What is the difference between UVA and UVB rays? n.d.)

(UVB): This type of ultraviolet radiation has more energy than UVA rays but stays in the epidermis, the outermost layer of the skin. They are responsible for activating melanin and the bikini mark appearing on your skin, but they are also responsible for causing sunburn, whether redness, flaking, or wounds. (What is the difference between UVA and UVB rays? n.d.)

(UVC): Invisible rays that are parts of the energy that come from the sun. The ozone layer prevents most UVC radiation from reaching the Earth. In the medical field, UVC radiation can also arise from special lamps or a laser beam and is used to kill germs or to help wounds heal. (NCI Dictionary of Cancer, 2011)

2. BACTERIA

Bacteria are single-celled prokaryotic organisms, found almost everywhere on Earth. They are vital to the planet's ecosystems. Some species can live in extremely extreme conditions of temperature and pressure.

The human body is full of bacteria it is estimated to contain more bacteria than human cells. Most of the bacteria found in the body do not cause any harm, on the contrary, some are beneficial. A relatively small number of species are the ones that cause disease. (Bacteria, n.d.)

2.1. Common pathogenic bacteria found in the environment

Currently, a danger to the health of the planet and those of us who inhabit it is pollution. Not only garbage and waste reach the environment, but also antibiotics and their metabolites, resistant bacteria, and resistance genes, all of them part of what have been called 'emerging pollutants', which although they are not new, in recent years, thanks to scientific and technological advances, it has been possible to detect and analyze them with greater precision. Establishing that they have a great capacity to maintain, amplify, and disseminate at an environmental level, becoming a danger to nature and human and animal health. (Tue, n.d.)

The most common bacteria in the environment are mostly enteric bacteria, from the gastrointestinal tract of animals and humans, called fecal bacteria, whose ability to survive and reproduce in water is restricted due to the physiological stress of the aqueous environment. (Ríos-Tobón et al., 2017)

Within the bacteria established as water contaminants, Gram-negative bacteria have been isolated, especially those belonging to the genera Pseudomonas, Flavobacterium, Gallionella, Aeromonas, Vibrio, Achromobacter, Alcaligenes, Bordetella, Neisseria, Moraxella, and Acinetobacter. However, the bacterial group that meets the characteristics of potential bioindicator of water quality is that of coliform bacteria, Enterobacteriaceae or Enterobacteriaceae, facultatively anaerobic, non-sporulating, gas-producing and glycolytic lactose fermenters, which generate acids as a final product. They correspond to 10% of human and animal intestinal microorganisms, so their presence in water is associated with fecal contamination and indicates inadequate treatments or subsequent contamination. (Ríos-Tobón et al., 2017)

This group includes genera Escherichia, Edwarsiella, Enterobacter, Klebsiella, Serratia, and Citrobacter. The latter four are found in large quantities in water sources, vegetation, and soils, so they are not necessarily associated with fecal contamination and do not pose or necessarily pose an obvious health risk. However, species of genera Enterobacter and Klebsiella colonize interior surfaces of water pipes and storage tanks, forming biofilms in the presence of nutrients, warm temperatures, low concentrations of disinfectants, and long storage times. (Ríos-Tobón et al., 2017)

Some other gram-negative genera implicated in waterborne diseases are Aeromonas, Neisseria, Moraxella, and Acinetobacter. Although gram-positive bacteria are not very common in water sources, some genera represent this group: Micrococcus, Staphylococcus, and Enterococcus. E. faecalis affects humans, inhabiting their gut, so it is also considered an indicator of fecal contamination, to mention a few. (Ríos-Tobón et al., 2017)

2.2. Common pathogenic bacteria found in the food industry sector

Pathogenic bacteria in the food industry can cause outbreaks that affect the health and safety of consumers. Below, we'll go over 5 very common bacteria in the industry, delving into what foods tend to "lodge" and what damage they cause. (Papelmatic, 2019)

Escherichia coli or E. coli: Escherichia coli lives on meats, usually beef, that are either raw or have not been cooked properly. It also lives in liquids that have not been treated, such as unpasteurized milk or contaminated water. It causes stomach cramps or diarrhea and is especially dangerous because it is sometimes asymptomatic (they are present in the urine in higher than normal amounts). (Papelmatic, 2019)

Listeria Monocytogenes: Found in ready-to-eat foods (unpasteurized beef, chicken, fish, or milk). Unlike other bacteria, it can survive in the cold, so it can reproduce in refrigerators. Listeria affects the body in many different ways: it can cause fever, headaches, diarrhea, etc., and is especially dangerous in pregnant women. (Papelmatic, 2019)

Campylobacter jejuni: Found in foods that have not been treated or have been cooked incorrectly. It is found in raw milk, contaminated water, raw beef, chicken, or fish. It mainly affects the stomach, causing diarrhea cramps, and sometimes even headaches. Infants and children under the age of one are especially susceptible to this bacteria. (Papelmatic, 2019)

Salmonella: Salmonella, the other well-known salmonella along with Listeria, lives in raw or undercooked eggs, dairy products, raw beef, chicken, and fish. It causes diarrhea, fevers, and headaches and, as with Listeria, is especially dangerous in pregnant women. (Papelmatic, 2019)

Yersinia enterocolitica: Yersinia is present in raw meats, fish, and seafood, as well as in untreated dairy products. It mainly affects the stomach, causing diarrhea, vomiting, and pain and, although its action is immediate, it usually lasts from seven days to three weeks. (Papelmatic, 2019)

3. UVC FOOD DISINFECTION PROCESS:

The germicidal effect of UV radiation is linked to the energy associated with the wavelength or frequency of UV light that is capable of producing photochemical damage to the nucleic acids of microorganisms. Several studies have examined the applicability of UV radiation in the inactivation of pathogens for water disinfection, several studies reveal that a wavelength around 265 nm has a relatively greater inactivation effect on organisms compared to other wavelengths. (Rossel Bernedo et al., 2020)

Ultraviolet light radiation penetrates the cell wall of organisms and is absorbed by DNA and RNA dimerized two bases (binds them together with a double bond), which prevents reproduction or causes cell death. Dimerization of two thymines is the most efficient for inactivating microorganisms. (Rossel Bernedo et al., 2020)

4. WHY IS UVC DISINFECTION A BETTER OPTION THAN OTHER FORMS OF DISINFECTION?

Unlike chemical water disinfection methods, UV radiation provides rapid and efficient inactivation of microorganisms through a physical process. When bacteria, viruses, and protozoa are exposed to the germicidal wavelengths of UV light, they become unable to reproduce and infect. UV light is effective against pathogenic microorganisms, such as those that cause cholera, polio, typhoid, hepatitis, and other bacterial, viral, and parasitic diseases. (Introduction to UV Disinfection, n.d.)

Control bacteria.

Keeping viruses, bacteria, and fungi under control is one of today's top priorities. There are several methods for disinfecting and sanitizing surfaces, air, and water, with extensive studies to support them, and one of them is UV-C light at specific wavelengths.

The action of UV-C or UV-GI light

Direct exposure to UV-C light, at wavelengths around 253.7 nm, in different microorganisms such as viruses, bacteria, fungi, yeasts, and protozoa destroys nucleic acids and damages their DNA/RNA, causing damage to their molecular structures. The effect achieved is disinfection by sterilization, which makes them incapable of reproducing and, therefore, eliminates their ability to infect.

How does ultraviolet light destroy microorganisms?

Generally, the entire spectrum of ultraviolet lights manages to inactivate most microorganisms, however, in air and surface disinfection applications, only UVC lights are recommended because they have the appropriate wavelength.

UV lights destroy microorganisms by damaging their structure of nucleic acids and proteins. Effectiveness depends on the dose of radiation received as well as the susceptibility of the microorganism to be controlled. Their DNA or RNA is destroyed, preventing their reproduction, making it an effective solution.

How does UV light disinfection work?

Ultraviolet (UV) light is a form of light invisible to the human eye, occupying the portion of the electromagnetic spectrum located between X-rays and visible light. For example, the sun emits ultraviolet light, although the Earth's ozone layer absorbs much of it, otherwise, it would be harmful to humans, not just bacteria. Disinfection and sterilization with ultraviolet light are highly effective if used correctly.

UV light as such was discovered in 1800 by a German astronomer named Friedrich William Herschel, who used a glass prism with different colors of light to experiment with sunlight and discovered an invisible light that was initially called "Ultra-Red." Johann Wilhelm Ritter also carried out experiments in 1801. He found a form of light beyond the violet end of the spectrum. He referred to this light as chemical rays, but it was later called ultraviolet light.

Method for scientific experimentation of bacterial control with UV light in a biology laboratory.

1. Weigh 40 g of agar on a sheet of paper after that it is placed inside the Beaker. Pour 1L of purified water and mix it with the agar until it is free of any lumps and then pour it into the Petri dishes.

2. Place the Petri dish on the tripod and the mesh for the lighter. It ignites and regulates the flame.

3. Wait 3 minutes until the mixture reaches boiling point. When the 3 minutes have passed, remove the petri dish with tongs.

4. It waits for it to cool and solidify, becoming a mixture with a jelly-like texture. While the agar is left to rest, the handle is heated in the lighter.

5. Once the handle turns bright red, the Petri dish is scratched in a consecutive left-to-right motion.

6. Sterile swabs are taken and passed over the surfaces from which the sample is to be taken. When we have the samples, the swab is rubbed over the incisions made with the loop. Wait for the bacteria to start growing.

7. After a day, growth is observed in the crops, which is an indicator that it was done properly.

8. After a week, a very large growth is observed, allowing us to see spots of different colors in the crop. UVC light is used to reduce the size of the spots.

CONCLUSIONS.

Bacterial control with UV lights is an effective and necessary solution to ensure food safety in the industry. As we have seen throughout this presentation, bacteria can contaminate food and cause serious illness in consumers. That's why it's crucial to implement preventative measures like using UV lights to kill bacteria and keep food safe for human consumption. In the food industry, bacteria can cause numerous infections, by ingestion, which could be a danger to humans.

UV-C sterilization technology has evolved, with improvements in UV lamps and disinfection systems. It has become a widely used option in the disinfection and sterilization of surfaces, air, and water.

Ultraviolet light does not alter the characteristics of the products to which it is exposed, such as water, preserving its composition, flavor, and color. In addition, it can be used in different environments and surfaces, improving the quality and safety of products.

In conclusion, the results of this research demonstrate that the use of UV lights is an effective method to control the presence of bacteria in the food industry. With the experimental part, the effectiveness of the bacteria in the different areas of work in the industry was verified. In addition, this method has advantages over other bacterial control methods, such as the absence of toxic residues in the treated food.

However, we have also found that implementing this method requires significant investment in equipment and training of the personnel in charge of using it. It is important for companies in the food industry to carefully consider these costs before deciding to adopt this technology.

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